

## AL12 - Online Shunting of Pots in Hirakud Potline

Pratap Sahu<sup>1</sup>, Debasish Mallik<sup>2</sup>, Ravi Pandey<sup>3</sup>, Goutam Das<sup>4</sup>, Samir Sahu<sup>5</sup>, Atanu Maity<sup>6</sup>  
and Nidhi Pandey<sup>7</sup>

1. Pot Room Head Smelter Hirakud P&S
2. Plant Head Hirakud P&S,
3. Department Head Pot room,
4. Section Head Pot room,
5. Section Head Pot room,
6. Department Head Process Control,
7. Section Head Pot Room

Hirakud Smelter, Hindalco Industries Pvt. Ltd, Sambalpur, Odisha

Corresponding author: pratap.s@adityabirla.com

### Abstract

Hirakud smelter (HKD), a unit of Hindalco Industries Limited is a part of Aditya Birla Group (ABG). Hirakud Aluminium is an integrated aluminium smelting complex that uses GAMI technology and is one of the oldest smelters in India established in 1959. Half of the potline was converted from Søderberg to prebake in 2009 and it has its own inherent challenges in terms of technology and retrofitting the old pots into prebake pots. Aluminium production is a continuous process. Today in modern smelters, pot shutdown and start-up are extremely critical operations, because of the level of energy surrounding the process (electrical and mechanical). As pot stoppage is a very critical activity for productivity as well as for pot life, a sustainable approach is developed to do online shunting of old pots. Various initiatives are applied during day-to-day operation and maintenance practices which help to sustain and maximize the production volume by reducing power disturbances. This paper presents a study of online shunting and its implications in Hirakud smelter.

**Keywords:** Aluminium reduction cell, Captive power plant, Thermal balance, Online shunting.

### 1. Introduction

An aluminium smelter potroom can contain hundreds of electrolytic cells or pots that are connected electrically in series. Hirakud smelter has five potlines with 12 rooms comprising 705 pots which are connected in series. Molten aluminium is produced in each pot by Hall-Héroult Process. Optimizing energy use, preventing downtime, and reducing costs of replacement are the key to improve potline performance. Every pot has a life cycle of approximately 2000 days. Critical and high aged pots are the poor performers in the line which drags down the overall current efficiency of the potline. Henceforth, the critical or high-aged pots need to be relined in regular intervals to avoid failure and meet the target production.

In Hirakud smelter on average yearly 140 pots are planned for relining. But previously due to several challenges, it was mandatory to take load reduction (LR) or power outages during planned or unplanned shutdowns. Due to frequent power reduction or power outages, the pot thermal balance gets disturbed, and some severe issues can take place during power resumption like significantly increasing chances of cooling crack formation due to thermal shocks and liquid metal penetration in the cathode blocks. The cathode deterioration may result in increasing the chances of pot failure thus decreasing the pot life.

To compete in the global market in terms of sustainability and higher productivity with quality, each smelter has to work strongly on the probable factors which might appear as major setbacks

in the future. Most modern smelters are adopting innovative approaches to have minimum power disturbances in the potline and have a stable operation. On the other hand, HIRAKUD had to find a way to shunt the pots in a planned manner with its operating challenges.

## 2. Operational Challenges in Online Shunting

Power interruptions as well as planned reduction can be difficult to manage due to challenges in the thermal balance of the pot. At reduced internal heat, pots will cool and cause operational difficulties. Additionally, smelters also have pots with different designs and age groups, which react differently to amperage reduction. HIRAKUD Smelter in its 85 kA potlines has its own limitations and potline current reduction and power outages with old shunting practice of the pots or pot leakages were pulling down current efficiency. Any reduction or outage has a very adverse impact both in the potline and in the thermal power plant KPIs. Any planned or unplanned pot stoppages required 10-20 minutes power reductions. Besides these, the following challenges are persisting in HIRAKUD 85 kA smelter:

- HIRAKUD smelter is the oldest end-to-end potline with pre-baked technology operating at 85 kA hence online shunting at full current is extremely risky due to a single connecting point in the riser and heavy sparking during shunting.
- Shunt alignment was a big issue in the potline due to frequent insulation failure of studs and sleeves. The requirement of electric overhead travelling (EOT) was a must for every shunt alignment.
- Due to improper thermal balance and huge heat dissipation from the side shell in 85 kA pots, the ledge profile especially at the conner anodes area gets extended which restricts the lowering of anodes and thereby, lowering pot voltage below 1.5 V becomes extremely difficult during online shunting.
- Also, shunt alignment (Figure 1) during emergency shunting of pots takes around 20-30 min. Even high safety risk is associated with this activity due to heavy sparking.
- Being the oldest smelter, the busbar condition is not suitable enough to accommodate the shock due to power disturbances. In a different location, welding cracks, which are already persisting get propagated due to this shock and thus worsen the conditions.
- Improper busbar ventilation and accumulation of bath beneath the busbar.
- Due to frequent power interruptions, the older pots above 2000 days get severely affected and become prone to failure.

## 3. Process Challenges

Apart from operational challenges, planned or unplanned shunting both lead to several process abnormalities due to power interruptions. These include thermal shock in cathodes, variation in bath chemistry, high anode effect frequency (AEF), pot instabilities, high cathode voltage drop due to sludge formation, and reduction in pot life. It has been revealed during the pot autopsy that cracks and ratholes (Figure 2) were developed due to thermal shock because of frequent power interruptions.



Figure 1. Sud bolt fixing for shunt alignment: before (left) and after alignment (right).



Figure 2. Rathole developed from cracks during power interruptions.

#### 4. Methodology Used

To avoid unplanned reduction and power outages, the HiraKud team has brainstormed all possible opportunities for online shunting. Standard Operating Procedure (SOP) and Hazard Identification and Risk Assessment (HIRA) were prepared, and training was imparted to the team to execute the job safely. All the safety precautions like wearing fire resistant suits, cleaning of shunts, arrangements of emergency tool kits, usage of insulated mats during shunting, alignment of shunts, usage of a pneumatic wrench, and usage of shunt alignment device, were implemented. With the adaption above practices as of date, 100 pots have been shunted successfully with 100 % safety compliance.



**Figure 3. The previous method of tightening the shunt by hand ratchet.**



**Figure 4. The latest method of tightening the shunt by pneumatic wrench.**

## 5. Steps for Online Shunting of Pots

The following steps were adopted for the online shunting of pots without taking power reductions or power outages:

- Brainstorming was performed by the team members with a SWOT (strengths, weaknesses, opportunities and threats) analysis.
- Development of SOP and HIRA for efficient and safe execution of the online shunting activity.
- Imparting training of SOP to the workforce for carrying out the activity efficiently and safely.
- Bath and metal were tapped before shunting to prevent spillage of bath on the potroom floor and below during the lowering of the pot voltage.
- Then the anode beam was lowered manually until the pot voltage came down to below 1.5 V.
- In case the voltage could not be brought below 1.5 V, an anode was lowered to lower the voltage. In this method one anode was made to slip down to touch the heel metal, thus short-circuiting the pot and bringing the voltage below 1 V.
- Insulating cloth was wrapped around the contact point of the shunt with the bus bar to prevent spark flares from coming in contact with the crew.
- With the help of a pneumatic wrench, the bolt tightening is accomplished.

A unique approach was adopted:

- Inhouse fabricated tool used for online shunting.
- The scientific approach for tracking the critical pots on the basis of Fe increase, pot age, cathode voltage drop (CVD), pot noise/shakiness, etc., was used for planned shutdown.
- Training and skill enhancement of shop floor people in challenging conditions.
- Managing space constraint as line was converted, and it consists of end-to-end pots; a very small gap is available for movement and completion of all activities.

## 6. Results

Due to online shunting, Hirakud potlines have experienced many tangible benefits:

- The power outage time got reduced from 12.7 h to zero and LR got reduced 108 h to 0.6 h in the last 12 months.
- Production loss was minimized by 17.53 MT monthly equivalent to 508 000 US\$ per year.

- Reduction in anode effect frequency by 0.2/day has been achieved due to the drastic reduction of LR and outages during online shunting.
- A reduction in DC energy consumption by 65 kWh/t Al has been observed due to online shunting.
- Also, disturbances in process parameters have been improved resulting in better pot stability.

Apart from these tangible benefits, the Hirakud potlines team has experienced a boost in confidence level and working conditions on the potroom floor have been improved due to proper planning, coordination, and adoption of improvised methodologies. At the rectifier end, unnecessary tap operation/switching during LR and outage period reduced, thus their reliability and maintenance cost also reduced, and power plant operation was also stabilized with lower no off-load throws. In financial year 2022, 590 load reductions, i.e., 1.6 load reductions per day occurred, whereas in financial year 2023 only 182 load reductions (i.e., 0.9 load rejections per day) happened. This is illustrated in Figures 6 and 6, and in Table 1.

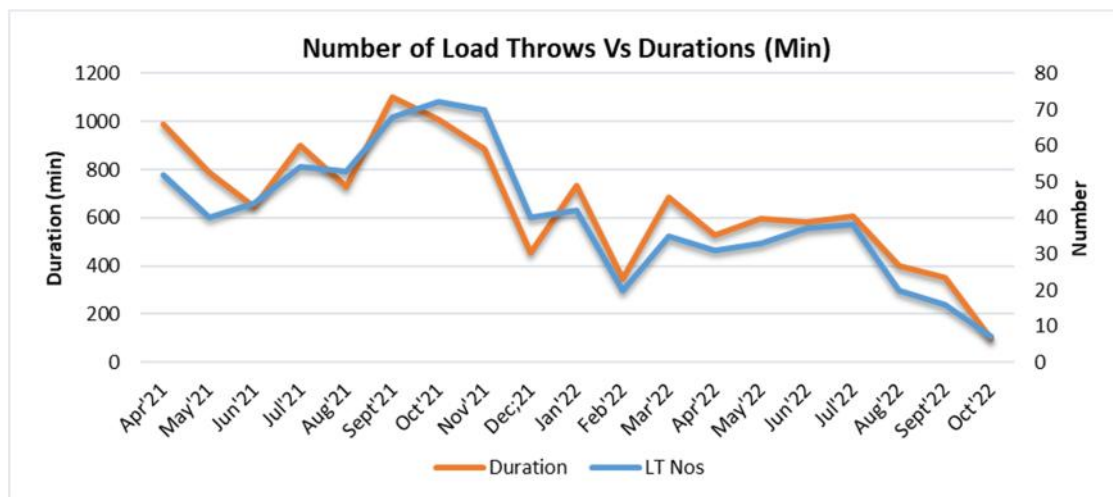


Figure 5. Number of load throws before and after online shunting.

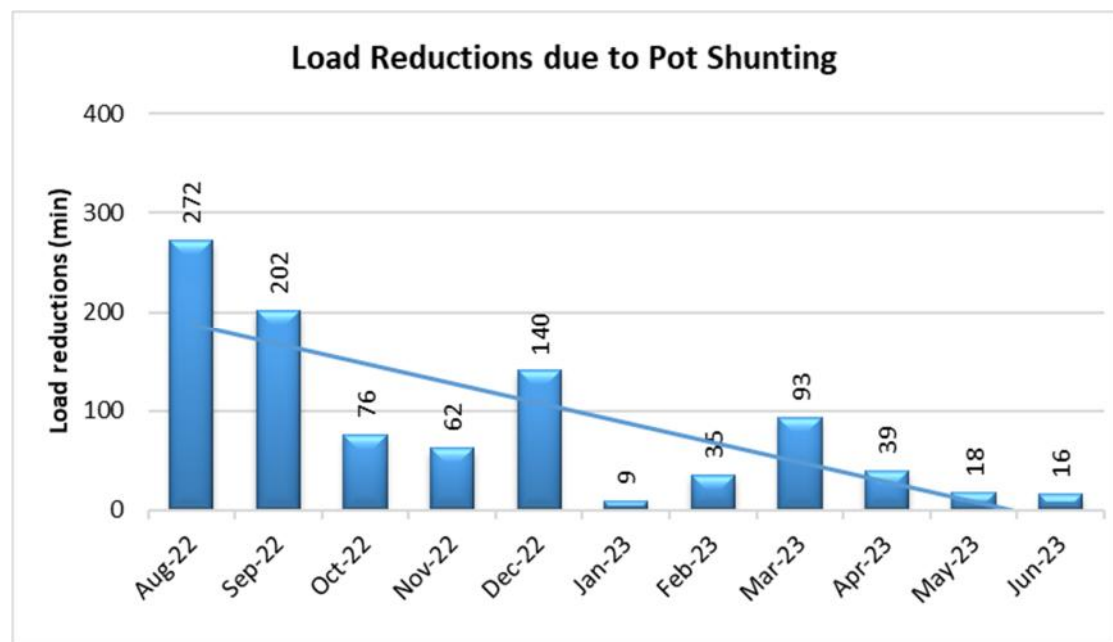


Figure 6. Number of load reductions before and after online shunting.

**Table 1. Load reductions and power outages in 2022 and 2023.**

Outage Data in min (Period July'22-Aug'22)			LR Data in min (Period July'22-Aug'22)		
Line	Total duration in min	Avg/ month	Line	Total duration in min	Avg
Line-1	459	30.6	Line-1	4173	278.2
Line-3	248	16.53	Line-3	2087	139.33
Line-4	1060	70.66	Line-4	229	15.26
Outage Data min (Period Sept'22-Dec'22)			LR Data min (Period Sept'22-Dec'22)		
Line	Total duration in min	Avg	Line	Total duration in min	Avg
Line-1	34	8.5	Line-1	448	112
Line-3	0	0	Line-3	131	32.75
Line-4	175	43.75	Line-4	33	8.25
Outage Data min (Period Jan'23-March'23)			LR Data min (Period Jan'23-March'23)		
Line	Total duration in min	Avg	Line	Total duration in min	Avg
Line-1	12	4	Line-1	27	9
Line-3	20	7	Line-3	77	25
Line-4	42	14	Line-4	33	11

## 7. Conclusions

To reduce LR and power outages during pot shutdown, the Hirkud plant team has adopted improvised methodologies which helped to achieve the desired results. The usage of in-house developed tools tackle prior shunt alignment, and stoppage of pots. A criticality matrix helped to reduce unplanned shutdown numbers and the risks associated with online shunting. Proper planning and execution of planned shunting have helped Hirkud smelter to achieve the highest-ever metal production in financial year 2023 with the lowest specific energy consumption. The online shunting also helped the thermal power plant to improve its KPIs, such as like plant heat rate (PHR) and plant auxiliary consumptions.

## 8. Acknowledgement

We would like to extend our sincere gratitude to the following leaders of Hirkud Smelter: Mr. K.N Pandey and Mr. Debasish Mallik who were spearheading this project and made it successful.